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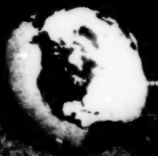
NEWSLETTER OF THE NATIONAL SCIENCE FOUNDATION

OCTOBER 1995

WHERE ON EARTH ARE WE GOING?



A Look at the Planet's Ever Changing Face

INSIDE: TRAINING TECHNICIANS FOR A COMPETITIVE FUTURE

NSF HELPS TWO-YEAR COLLEGES TRAIN TOMORROW'S TECHNICIANS

The Department of Labor predicts that in the next five years, 80 percent of the nation's new jobs will require more than a high school diploma but less than a four-year degree. Clearly, two-year colleges are places with a future.

> ***"We want to break down some of the myths and show that manufacturing is in fact a high-tech kind of career choice."***

At Sinclair Community College in Dayton, Ohio, the future lies in high-tech manufacturing, according to David Harrison, manager of an NSF Advanced Technology Education (ATE) grant. Industry groups — including plastics, automotive, and machinery and metal working — are working with Harrison to develop a two-year degree program which includes physics, chemistry, math, and computer programming.

"We want to break down some of the myths," Harrison says, "and show that manufacturing is in fact a high-tech kind of career choice." Harrison's Advanced Integrated Manufacturing Center is one of 58 ATE projects that started with a $14.6 million budget in 1994. The preliminary results, including new curricula and teacher training conferences, were good enough that the 1995 award money rose to $23.5 million, says ATE Director Elizabeth Teles. ATE programs now span 25 states, Washington D.C. and Puerto Rico.

As one of the first programs to address the educational needs of science and engineering technicians specifically, NSF's ATE program also sponsors two-year programs in aerospace technology, biotechnology, chemical technology, computer technology, electronics, engineering technology, geographical information systems, mathematics, and physics.

ATE started as part of the 1992 Scientific and Advanced Technology Act. Congress was concerned that U.S. industry would lose its competitive edge without highly trained technicians. NSF was charged with creating an educational program.

Congress' concern was not misplaced, according to Teles. "Industries are asking for a work force that has strong background knowledge in math, science and technology," she says. While ATE programs take different approaches, all of the graduates need more than rote skills if they are going to keep pace with changes in the workplace, Teles explains.

The major focus is on two-year college students but most ATE programs and projects go beyond that. They create teacher development programs, support curriculum development and program improvement for high school students who will seek technical careers, and cooperate with four-year colleges and universities in program development.

The program is a joint effort of the Division of Undergraduate Education and the Division of Elementary, Secondary and Informal Education. ◉

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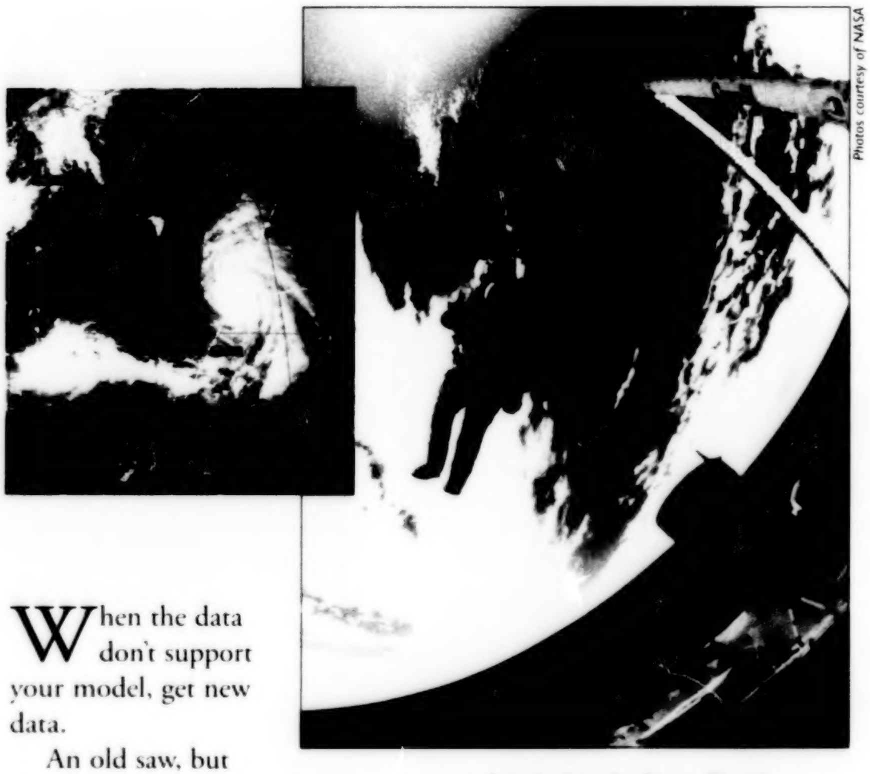
NEW DATA GIVE A CLEARER VIEW OF GLOBAL CLOUD COVER


Photos courtesy of NASA

▶ Attached to the Space Shuttle Discovery, LITE measures cloud cover on Earth. Inset: Earth as seen in a standard satellite image.

When the data don't support your model, get new data.

An old saw, but two NSF grantees found that it sometimes works. Atmospheric scientists David Randall of Colorado State University and James Coakley of Oregon State University study the earth's atmosphere and the processes of pollution transfer and global warming.

To validate their mathematical models of atmospheric change, Randall and Coakley needed data on clouds, since clouds have a dramatic effect on the earth's heat retention. They used conventional weather satellite imagery data, the same that are used for TV broadcasts and newspapers, to identify key information concerning the global cloud cover. When the satellite data failed to match their models' predictions, they were unsure if the models or the data were off.

Until recently, satellite data were among the only measures of global cloud cover. Now, data from NASA's new Lidar In-Space Technology Experiment (LITE) have the potential to greatly improve the scientists' interpretation of satellite observations. Randall and Coakley realized this potential when they used the information gathered during LITE's maiden voyage last fall. LITE flew as an attachment to the Space Shuttle Discovery.

LITE is essentially an optical radar. By bouncing pencil-width laser beams off the clouds and earth, scientists can gather high-resolution, three-dimensional information about number of clouds and arrangement of cloud layers.

LITE's superiority to satellite imagery data stems from the fact that conventional weather satellite data have relatively coarse resolution, measuring only two to four miles at a time. To analyze cloud coverage, scientists take this two- to four-mile grid and mark each box as cloudy or clear. As Coakley points out, however, clouds generally do not move in grid patterns. They are often half inside a grid, half outside. Furthermore, satellite data often miss the high wispy clouds that help to keep the earth's heat from escaping into space.

LITE provides far more relevant information for evaluating models such as Randall's and Coakley's. As it turned out, the cloud patterns revealed in the LITE data were much closer to their predictions.

Coakley's pleasure in the new data was evident as he told an audience at the American Geophysical Union earlier this year: "It is rather satisfying to see the layered structure of cloud systems that we had been anticipating in the LITE observations." ⊙

WHERE ON EARTH ARE WE GOING?

A Look at the Planet's Ever Changing Face

Political scientists may debate whether nations are moving left, right, or center, but geoscientists know that Africa is moving north at about 10 millimeters a year (mm/yr), India is moving north as much as 40 mm/yr, Turkey is swinging west at about 25 mm/yr, and parts of southern California are moving north-by-northwest at about 35 mm/yr.

And that's not half the story.

The human race has always suspected that Planet Earth is not stable. The Noah Story, Joshua at Jericho, the mythic Lost Continent of Atlantis — all have been, to some degree, attempts by early peoples to explain the physical reforming and deforming of the surface of the earth.

Early in this century, however, a less mythic, more scientific explanation was developed: the theory of plate tectonics incorporating continental drift and seafloor spreading.

Plate tectonic theory was gradually constructed over some five decades by a cadre of geoscientists from many nations: the Americans Robert Dietz and Harry Hess, Germany's Alfred Wegener, Alexander du Toit of South Africa, England's Frederick Vine and Drummond Matthews, Scotland's Arthur Holmes, Canada's Tuzo Wilson and Lawrence Morley, and scores of others who have been brilliantly filling in the spaces.

The theory explains the genesis of the 13 major plates (and a number of smaller fragments) that together form the earth's thin (0-100 km deep) surface crust and lithosphere. The plates move sluggishly about on the asthenosphere, a layer of ductile, partly molten rock up to 700 km deep that is a "transition zone" to the earth's mantle and white-hot core.

Plate tectonic theory explains how the plates have moved over millions of years, but not how or where they're moving today. To obtain that data on speed and direction, the geosciences have adopted a series of space technologies, beginning with NASA's Very Long Baseline Interferometry (VLBI). Because it is anchored to quasars, which don't appear to move relative to the solar system, VLBI provides what Kristine Larson* of the University of Colorado/Boulder calls "an inertial frame of reference" for comparative measurements here on Earth.

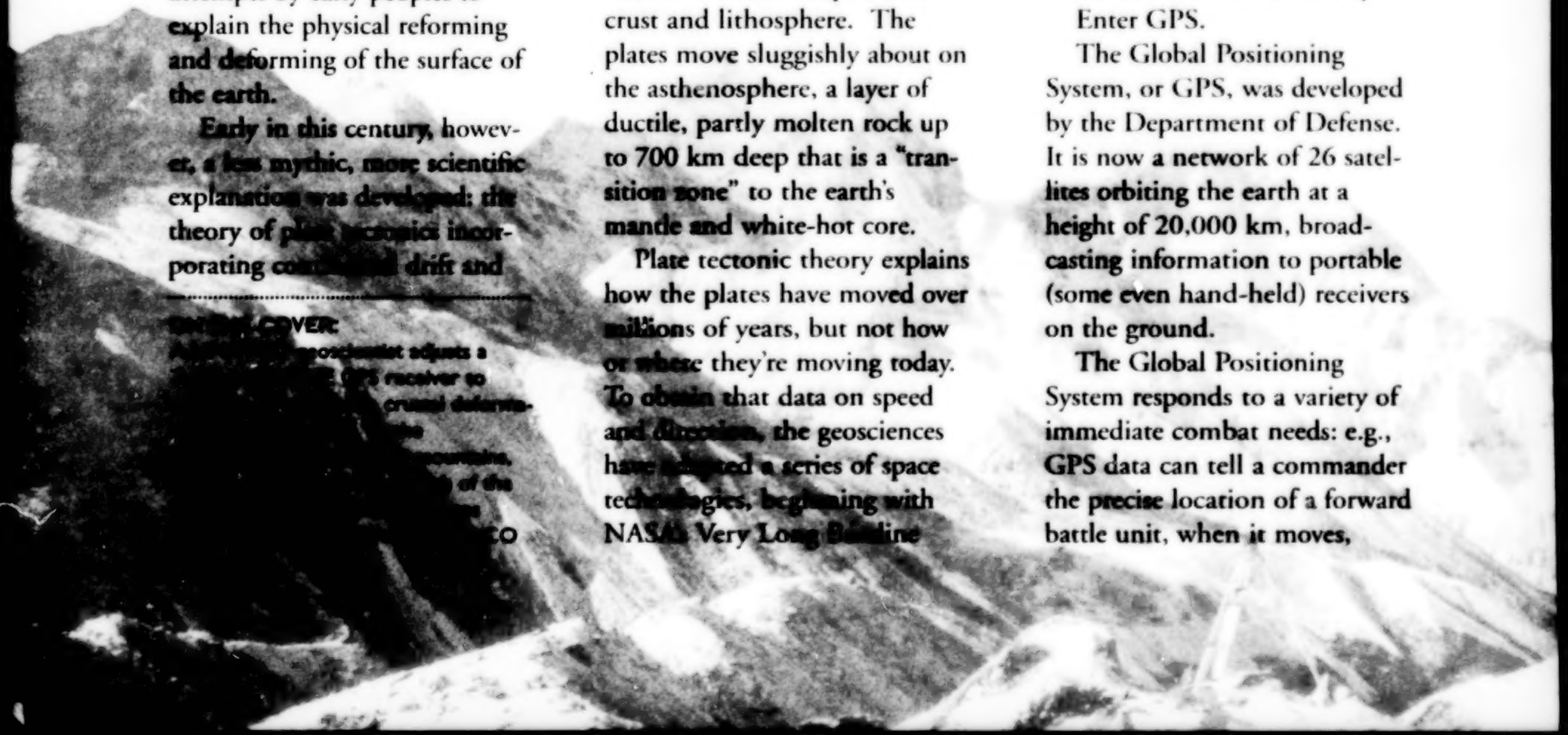
But VLBI is also complicated, expensive, and at its best measuring very large areas over long periods of time. After several years of experience with VLBI, geoscientists looked around for a simpler, cheaper, and more portable system to measure smaller space/time increments of crustal activity.

Enter GPS.

The Global Positioning System, or GPS, was developed by the Department of Defense. It is now a network of 26 satellites orbiting the earth at a height of 20,000 km, broadcasting information to portable (some even hand-held) receivers on the ground.

The Global Positioning System responds to a variety of immediate combat needs: e.g., GPS data can tell a commander the precise location of a forward battle unit, when it moves,

ON THE COVER:
[illegible] geoscientist adjusts a [illegible] GPS receiver to [illegible] crustal deforma- [illegible] the [illegible] mountains, [illegible] of the [illegible] CO

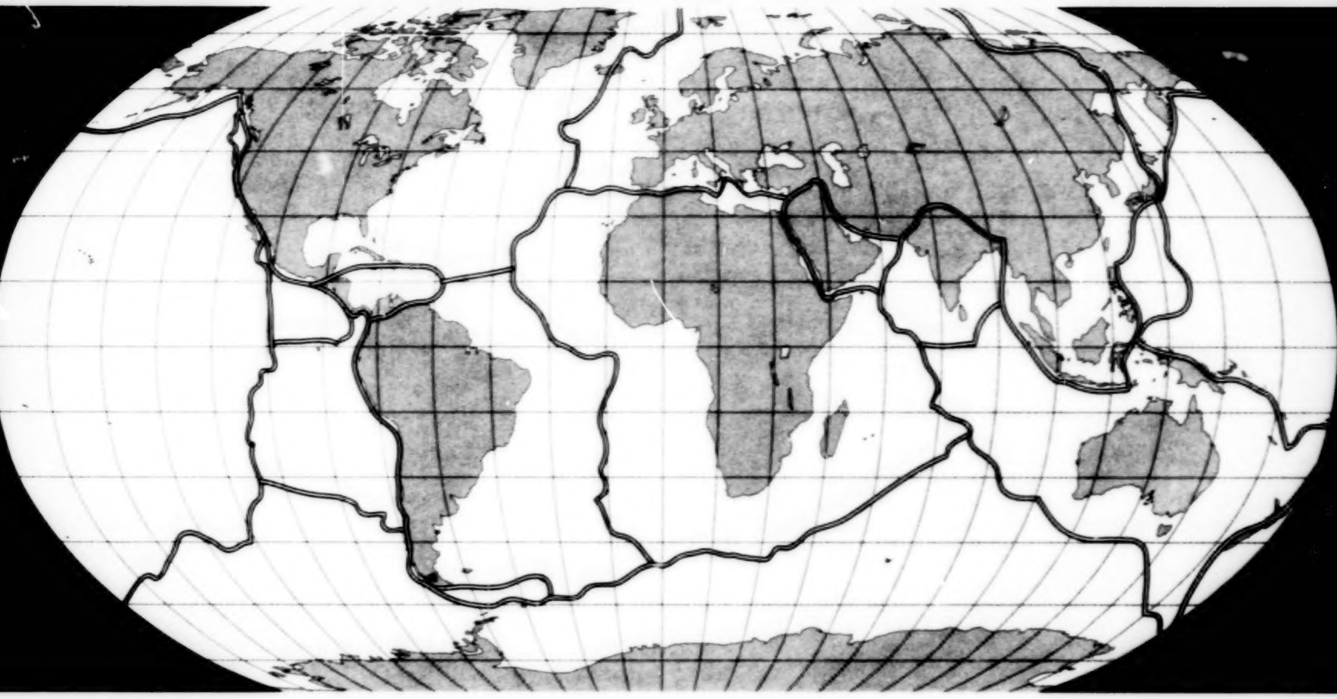


where it goes, and how fast. However, almost from the first day it appeared, GPS was adopted by the civilian community as well for ship navigation, aircraft guidance, and land surveys, for example. That's also when the NSF Division of Earth Sciences began funding the University Navstar Consortium, or UNAVCO, of Boulder, CO. This consortium of 63 institutions cooperatively purchases GPS equipment, matching NSF's grants approximately dollar-for-dollar. According to its charter, UNAVCO provides GPS equipment and technical support to "university-based investigators in the geosciences...[in order to] better understand the behavior of the Earth and the global environment..."

Over the past 10 years, UNAVCO has acquired 120 GPS receivers, and the price has been steadily dropping, from an initial $150,000 to just under $20,000 each — with lower prices still ahead. UNAVCO has loaned them out to scores of investigators, supplied the training to run them, and has helped in data collection, storage, and analysis. Those investigators are trying to answer the questions raised by plate tectonic theory: How fast do the plates move? Where are they going? And what happens where they meet?

Randolph Ware,* director of UNAVCO, believes that the GPS data being collected with NSF-UNAVCO help is part of a vital database that, one day, will help scientists determine where — and maybe even when — the next serious earthquake will occur.

"We're getting excellent data mainly — but not exclusively — from a number of plate boundaries where the earthquake activity is the greatest," says Ware. "For instance, Robert Reilinger* has been mapping the movement of the Anatolia Plate — Greece, Turkey, and the Caucasus — caught in the collision between the African, Arabian, and Eurasian Plates. Roger Bilham* has been up in the Himalayas obtaining data from 28 GPS stations scattered across Nepal, Tibet, India, and as far north as Urumchi, China. He is providing good baseline data on the convergence of the Indian and Asian plates. Then there's been a lot of activity, as you might expect, in California along the San Andreas fault line.



▶ The boundaries of Earth's 13 plates, as currently known. The planet's volcanic and earthquake hotspots are found along the boundaries of the most active plates, especially the rim of the Pacific plate.

"The margin of error in most GPS projects is now down to the millimeter level," says Ware, "but the data are getting better all the time."

Kristine Larson has been using GPS since 1988 to analyze Southern California's tectonics. "We know about the San Andreas fault. You can see it. But now we're learning about significant crustal movement throughout a network of hidden or 'blind' faults."

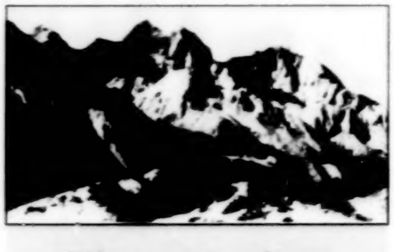
Larson has been looking at the hidden Santa Barbara Channel fault. "It's active. In

1925 it produced a magnitude 6.3 quake [i.e., a quake with a magnitude reading of 6.3 on the Richter Scale]. But instead of a shearing movement, as with San Andreas," says Larson, "we have a north-south compression, with the Channel Islands closing in on the City of Santa Barbara at a rate of about 5 mm/yr. It's similar to what we're seeing inland around Los Angeles. Pasadena, for instance, is moving south, closing in on Palos Verdes at about the same rate — 5 mm/yr — also as a result of plate compression."

But the West Coast is not America's only area of tectonic/seismic interest. The worst quakes to hit the U.S. were centered in the Mississippi Valley (the mag/8 New Madrid, MO, quake and aftershocks of 1811-12) and Charleston, SC (the mag/7 quake in 1886), as well as the mag/8 quake in San Francisco in 1906 and the mag/9.2 Alaska quake of 1964.

San Francisco and Alaska are perched on the edge of the North American Plate, relentlessly nudged by the constant motion of the Pacific Plate. Earthquakes happen there. But Missouri? South Carolina?

"For the Eastern Seaboard and the Midwest, the movement is more intraplate," says Klaus Jacob,* geophysicist with the Lamont-Doherty Earth Observatory. "The seafloor of the Atlantic is opening and spreading down the middle, separating the European and North American plates at a rate of about 1 cm a year. This 'Ridge Push' presses against the Eastern Seaboard, but the stress may be transmitted as far west as the Rockies.



"The margin of error in most GPS projects is now down to the millimeter level."

"Also, we know the Atlantic is now opening up for the second time," Jacob says. "Many old crustal fractures and faults may be reactivated by new stresses and strains." Noting that New York City and Boston have already had mag/5 and 6 earthquakes respectively ("The last one in New York was in 1884, so we're probably due for another"), Jacob notes the presence of a still poorly understood network of major old rifts and fault systems, linking tectonic and seismic zones that reach from Canada's Baffin Bay in the north to the Carolinas in the south, lying parallel to the Eastern Seaboard along the Appalachian chain. Another one persists along the still-active New Madrid rift system.

During the 1980-1991 decade, the U.S. Geological Survey's National Earthquake Information Center recorded 10 quakes in Massachusetts (the largest, a mag/3); 21 quakes in Maine (the largest, a mag/4.3); and 24 in New York (the largest, a mag/5.3). More recently, between June 22 and July 5, 1995, for example, American and Canadian seismologists recorded a 2.4 between Buffalo and Rochester, NY; a 3.5 some 80 km west of Winston-Salem, NC; a 3.7 about 40 km northwest of Chattanooga, TN; two mag/3 quakes 20 km west of New Madrid, MO; and seven "very minor" tremors in the Charlesvoix Seismic Zone 100 km northeast of Quebec.

In the shadow of this moderate but persistent seismic activity in the east, Klaus Jacob led a group of 30 scientists, developers, and government officials who drafted a new seismic building code for Greater New York City. As of February 21, 1996, therefore, any new structures going up in that metropolitan area must be built to withstand a mag/5 or 6 quake. Even blasé New Yorkers became believers.

But what are the chances of such a quake occurring in, say, a given 25-year period? B. F. Howell, Jr.,* geoscientist at Pennsylvania State University, presented his "estimated probabilities" in the April-June 1994 issue of *Seismological Research Letters.* Using earthquake data from the past century (1885-1984), Howell estimates an 85 percent chance for a mag/4.5 quake hitting the New York-Maine area, a 42 percent chance for a 5.3, and a 12 percent chance for a mag/6 within any given quarter century.

But then, says Howell, the past century could have been just a quiet prelude to the arrival of a large mag/7 or 8 quake. Meanwhile, the earth's plates continue to shift, bump, split, stretch, and crumple, to the continuing wonder of the tiny creatures scampering about their surfaces.

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* NSF grantee.

NSF IN THE NEWS

EARTH'S EARLY LIFE MAKEUP COMES INTO SHARPER FOCUS

▶ Researchers believe Earth's inner core is an iron-based crystal which influences the planet's magnetic fields.

Iron Crystal May Occupy Inner Core of the Earth

The earth's inner core may be one gigantic, iron-based crystal, according to a report in *The New York Times.* The report cited work by Drs. Ronald Cohen of the Carnegie Institution of Washington and Lars Stixrude of the Georgia Institute of Technology, who were supported by an NSF grant.

"My hypothesis is that it's like a diamond in the center of the earth," says Cohen.

The earth actually has two cores. The outer core is made of molten iron. But further in, pressure becomes so great that iron solidifies. Scientists had long thought this 1,500-mile-wide inner core unimportant, but now they are saying that a crystalline core could help explain the earth's magnetism.

Cohen and Stixrude described the iron core after examining data on the earth's internal temperatures and pressures. Then, using the Pittsburgh Supercomputer Center, the pair modeled their findings, coming up with three types of iron crystals.

The first, called a body-centered cubic, is found on the earth's surface. However, this crystal is unstable at high pressures and inner-core pressures are three million times greater than those on the earth's surface.

The second, called a face-centered cubic, was eliminated because of discrepancies between data on the earth's seismic waves and the way this crystal transmits waves.

Finally, the third, a diamond-like crystal, is called a close-packed hexagonal. Measured against pressure data temperature data and seismic data, the crystal worked well in the team's model.

Working with the hypothesis of a crystal core may allow scientists to learn more about the earth's magnetic field and magnetic poles.

Ungainly Fossil Mollusk 'Forrest Gump' of the Sea

Successful species aren't always the prettiest ones, two NSF-funded paleontologists confirmed when they dug an ungainly sea mollusk fossil out of Antarctica's Seymour Island.

Shaped like a gigantic paper clip with ribbing, the mollusk would have measured 12 feet if it could have uncoiled. "The world doesn't always go to the swift and the sleek," William Zinsmeister of Purdue University told the *Dallas Morning News.*

Zinsmeister and graduate student Anton Oleinik discovered the *Diplomoceras maximum*, a type of ammonite that became extinct 65 million years ago. The fossil is the most complete example of this species known, Zinsmeister says.

Diplomoceras were once thought to only survive in places free of competition. But now scientists say they were actually a very successful species that lived in the world's oceans for millions of years.

"They seem to have competed as well as their swift and agile cousins," Zinsmeister told *Science News.* "That's why I refer to the fossil as the Forrest Gump of ammonites."

ASIAN HIGH-TECH INDUSTRIES BECOME TOUGHER COMPETITORS

High technology firms in the United States are likely to face stiffer competition both for customers and for research staff as Asian high-tech industries continue to grow over the next 15 years. However, the United States may also gain new business and research opportunities in a technologically advancing Asian region.

Asia's New High-Tech Competitors, published by the Division of Science Resources Studies (SRS), makes these predictions and identifies South Korea and Taiwan as the countries which may become the next "Japans" in terms of high technology industrialization.

Larry Rausch, report author and senior analyst, studied nine Asian nations and separated them into three economic tiers:

- Advanced Industrialized Economies: Japan.
- Newly Industrialized Economies (NIEs): South Korea, Taiwan, Hong Kong and Singapore.
- Emerging Asian Economies (EAEs): China, India, Indonesia and Malaysia.

Rausch predicts that both South Korea and Taiwan will become even stronger contenders in the high-tech marketplace, where the United States has long been the leader. Rausch also notes that Malaysia had strong performances in parts of its economy and suggested that Malaysia may be the next Asian NIE.

"Increasingly, technology-related products, televisions, computers and other electronic items produced in these countries are being offered to U.S. consumers and they are buying them," Rausch says. He sees this trend continuing and expanding. "Aircraft and other aerospace products could be the next industries facing stiffer Asian competition."

According to the report, a growing Asian economy will also bring new business and research opportunities for U.S. high-tech industries and the science and technology community. These opportunities will come in the form of larger markets for goods and services and new collaborators in scientific and technological research.

However, Rausch also expects U.S. companies to face stiffer competition from Asia for the high quality scientists and engineers (S&Es) coming out of U.S. universities.

"We should not assume that the best S&Es graduating from U.S. universities will automatically choose to stay and work in the U.S. science and technology establishments," he says. "Not just the foreign students but also U.S.-born S&Es will be enticed to work in up-and-coming Asian high-tech companies and new research institutes."

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